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PROCESS FOR MONITORING AN AERIAL OR SPATIAL DISTRIBUTION

FIELD OF INVENTION

This invention relates to a process with which the distribution of structures on a surface or of particles in space may automatically be monitored. In the event of deviations from the required state, warnings may automatically be output locally or remotely and/or corrective action initiated. The process is, for example, suitable for automatically monitoring the success of cleaning, chemical conversion and/or coating of surfaces, such as metal or plastic surfaces without requiring human intervention. One area of application is, for example, monitoring surface conversion or coating operations in the steel industry and automotive construction. The process is, moreover, suitable for example for monitoring the spatial distribution of particles in a spray jet. In such a case, it is possible automatically to monitor, on the one hand, the angle of divergence of the spray jet and, on the other, the homogeneity of the particle distribution in the spray jet. Applications for this latter case are, on the one hand, spray drying or spray solidification of solutions, suspensions or melts with the aim of maintaining the space/time yield of such processes at optimum levels. If, however, the purpose of the spray jet is to coat a surface as uniformly as possible, the purpose of the process may be to maintain the coating process within the required range.

BACKGROUND OF THE INVENTION

It is known in the art to store images of a surface in digitized form on a data storage medium and to subject them to automatic image analysis from various viewpoints. US-A-4 878 114, for example, describes a processor-based optical system for assessing the roughness of a planar surface of a product. The system comprises an adjustable light source to illuminate the surface of a product. This system comprises n adjustable light source to illuminate the surface, a video camera and a device for storing the video output signal in digitized form and a processor for analyzing these digitized signals in such a manner as to determine a parameter which reproduces the roughness of the surface. The result of the image analysis is a single figure which characterizes the roughness of the analyzed portion of the surface. This result of the analysis contains no indication as to the existence and location of any particularly large deviations from the average roughness on the surface investigated.

nozzles result in a reduced space/time yield. If, however, the purpose of the spraying is to apply the particles as uniformly as possible onto a surface, clogged nozzles give rise to a non-uniform surface coating. When surfaces are coated by spraying liquid or solid particles, it may be of significance to the economic viability and the result of the coating process that the spray jet has a certain angle of divergence.

The uniformity of a surface in surface treatment processes or the uniform distribution of particles in a spray jet or the angle of divergence thereof are generally assessed by a visual assessment of the surface or spray jet either directly or from photographs. Human intervention is required for this purpose. Moreover, visual assessment may only be performed at certain intervals in time unless labor resources are to be occupied by devoting personnel exclusively to monitoring continuously the production result. If, as is generally usual, monitoring is performed only at certain intervals in time, there is a risk that defective products will have been produced between two periods of monitoring.

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is to provide automatic, continuous monitoring of processing or production processes, in which the quality of the result is manifested either as a uniform appearance of a surface or as uniform filling of a space with particles, and, in the event of disturbances, to output warnings and/or to analyze the causes of the disturbances and, where possible, to eliminate them.

The present invention accordingly provides a process for monitoring the distribution of structures on a surface or of particles in space, characterized in that:

(a) at least one two-dimensional image of the distribution is produced optically or electronically, is broken down into pixels and the brightness value of each pixel is stored in digitized form on a data storage medium;

(b) the image or a portion thereof is divided into a preselected number of image elements arranges in rows, wherein each image element comprises at least four pixels;

(c) the average brightness value of each image element is determined by averaging the brightness values of the individual pixels of this image element.

(d) the difference between the average brightness values of adjacent image elements is determined along a first specified row of image elements and recorded machine-readably on a data storage medium and/or output as a diagram in such a manner that a spatial correlation is obtained between the difference values and the position of the associated image elements on the image;

and, if desired,

(e) stage (d) is repeated with a preselected number of additional rows of image elements, which are substantially parallel to the first specified row.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1(a) Video image of a portion of a steel sheet phosphated with a film forming zinc phosphate solution. Image 11 cm X 8 cm

Figure 1(b) Video image of a portion of a steel sheet phosphated with a film forming zinc phosphate solution which has been damaged by scratching. Image 11 cm X 8 cm

Figure 2 (a) Graphical representation of the differences in brightness values of adjacent image elements of Figure 1(a). The successive lines in Figure 2(a) correspond to the successive rows of image elements in Figure 1(a).

Figure 2(b) Graphical representation of the differences in brightness values of adjacent image elements of Figure 1(b). The successive lines in Figure 2(b) correspond to the successive rows of image elements in Figure 1(b).

Figure 3(a) is an optically smoothed video image of a spray jet for applying underbody solvent. The image portion is about 16 cm X 12 cm.

Figure 3(b) shows the difference in brightness value of adjacent image elements of Figure 3(a) plotted in lines.

Figure 4 (a) is a schematic representation of the outer significant difference values of adjacent image elements in Figure 3(b), which indicate the delimitation of the spray jet.

Figure 4(b) illustrates calculation of the angle of divergence of the spray jet.

DETAILED DESCRIPTION OF THE INVENTION

The phrase "at least one two-dimensional image" in sub-stage (a) here means that one image or two or more image of the distribution is/are recorded. One image is generally sufficient for assessing a substantially flat surface. When assessing a spatial distribution or a strongly curved surface, however, it may be advantageous to record two or more images, the image planes from which form a specified angle relative to each other. In this manner, the surface or spatial distribution may be assessed from various viewing directions. A video camera is preferably used to produce the image. The image portion may here be adjusted by the focal length of the video camera and/or by the distance of the camera from the article to be assessed. If very small portions of an article are to be assessed, such as may, for example, be necessary for monitoring the conversion of metal surfaces, the video camera may be provided with a microscope attachment. This process obviously presupposes that the surface to be imaged or the spatial zone to be recorded is sufficiently well illuminated. It is, for example, possible to use an apparatus as described in US-A-4 878 114 for recording and storing the image data digitized form.

In sub-stage (b), the image or preselected portion thereof is broken down into a likewise preselected number of image elements arranged in rows. The maximum number of image elements is here determined by the resolution of the camera used. The term pixel is hereinafter used to denote the smallest possible portion of the image, determined by the resolution, to which a brightness value (grey-scale value) may be assigned. The number of image elements into which the image may be broken down accordingly corresponds at most to the number of pixels assigned thereto. In